The Economics of Regional Poverty-Environment Programs

An Application for Lao People's Democratic Republic

Piet Buys*
Kenneth Chomitz
Susmita Dasgupta
Uwe Deichmann
Bjorn Larsen
Craig Meisner
Jostein Nygard
Kiran Pandey
Nat Pinnoi
David Wheeler

World Bank

- **Authors' names are in alphabetical order. This research has been jointly supported by the World Bank's Development Research Group and Southeast Asia Poverty- Environment Nexus Program, with funding from the Norwegian Trust Fund for Environmentally-Sustainable Development. Our thanks to Zafar Ahmed for valuable comments and suggestions.**
-

World Bank Policy Research Working Paper 3267, April 2004

• Abstract

Program administrators are often faced with the difficult problem of allocating scarce resources among regions in a country when interventions are aimed at addressing multiple objectives. One main concern is the tradeoff between poverty reduction and improvement of environmental quality. To provide a framework for analysis, this paper develops a model of optimal budget allocation that allows for variations in three factors: administrators' valuation of objectives; their willingness to accept tradeoffs among objectives and regional allotments; and regional administrative costs. The results from an application of this model using information for Lao PDR show that simple poverty indicators alone do not provide consistent guidelines for policy. However, when different poverty indicators are embedded in an optimizing model that incorporates preferences and costs, the resulting provincial allocations are very similar. This suggests that adoption of a formal analytical approach to resource allocation can help promote the harmonization of regional policy guidelines.

1. Introduction

The lower Mekong sub-region, consisting of Cambodia, Lao PDR and Vietnam, is one of the poorest areas in Asia. With per-capita GDP's in the range $US 270-410, and poverty incidence rates of 35-40 percent, these three countries are experiencing serious natural resource degradation in rural areas and declining environmental quality in major cities. To improve its understanding of links between poverty and environmental degradation in the sub-region, the World Bank has undertaken a Poverty-Environment Nexus (PEN) study with a two-phase implementation.[1] The Phase I report, completed in October, 2002, provided numerous insights into the spatial relationships between environmental problem indicators and poverty in the three countries (Dasgupta, et al., 2003). A preliminary Phase II analysis has provided further understanding of spatial poverty-environment linkages, with a particular focus on the burden imposed on the poor by environmental degradation.

Concurrently with the World Bank PEN initiative, Cambodia, Lao PDR and Vietnam have begun to focus on poverty-environment linkages as they develop poverty reduction and growth strategies. In Lao PDR, the focal country for this paper, the PEN Phase I report has served as an input to the National Poverty Eradication Program (NPEP). While the NPEP addresses overall sectoral and macro policy issues, it also targets 46 priority districts for poverty eradication. The government has identified these districts using a comprehensive measure of poverty, as well as consideration for regional and provincial representation.[2] Yet to be determined, however, are the overall resource requirements for the priority districts, the allocation of resources across and within these districts, the magnitudes of central and local

[1] See "The Poverty-Environment Nexus: A Strategic Approach for Cambodia, Lao PDR, and Vietnam," (World Bank)
[2] The poverty measure includes consumption and asset indicators, and access to basic services and infrastructure.

government contributions, and relative sector priorities.

These problems typify work on the poverty-environment nexus, which is complicated by uncertainty over appropriate rules for the allocation of program budgets. Within countries, program administrators often use indicators such as poverty incidence to assign regional priorities. This approach provides equal budgetary allotments for all poor households if they are uniformly distributed across regions. However, recent poverty-mapping studies in Asia, Africa and Latin America have shown that this is often far from the case (Simler and Nhate, 2002; Dasgupta, et al., 2003; Lanjouw, et al., 1998). Even if budgetary allotments are equal, resource-constrained program planners have to confront difficult tradeoffs among multiple objectives: the number and proportion of poor households actually served; the average quality of services; and the associated degree of improvement in environmental quality.

The allocation problem may be compounded by regional differences in administrative costs. In this paper, we consider three spatial factors that affect these costs. The first is the settlement density of poor households. For program administrators and technical assistance workers, average transport times and costs are significantly lower in densely-populated areas. Such areas also benefit from scale economies in projects that improve community-level services (e.g., sanitation or access to safe water). The second spatial factor is poverty incidence. Areas with high poverty incidence have relatively low screening costs, because they have lower risks of benefits "leakage" to higher-income households. The third factor is overall population density, which affects monitoring and enforcement costs for natural resource conservation and pollution management programs.

How should poverty-environment programs accommodate these diverse concerns, and what are the implications for the use of priority indicators such as poverty incidence or the rate of natural resource degradation? To provide a framework for analysis, this paper develops a model of optimal budget allocation that allows for variations in three factors: administrators' valuation of objectives; their willingness to accept tradeoffs among objectives and regional allotments; and regional administrative costs. We explore the model's implications using provincial data from Lao PDR. Our results suggest that under real-world conditions, single indicators of poverty or environmental degradation may provide very poor guidance for allocating program resources. In many cases, priorities suggested by the indicator-based approach have large, *negative* correlations with priorities suggested by a more complete optimizing model. In light of these results, we believe that regional poverty-environment strategies should incorporate information on administrators' preferences and costs, as well as indicators of poverty and environmental damage.

The remainder of the paper is organized as follows. In Section 2, we use alternative poverty indicators to establish priorities for program budget allocation in Lao PDR. Unfortunately, we find that different indicators suggest very different priorities. In Section 3, we broaden the analysis with an optimizing model that incorporates administrators' preferences and administrative costs. We show that the indicators-guided approach reflects highly-restrictive assumptions about the parameters of the model. Using Laotian data, we relax these assumptions in Sections 4 and 5, and explore the consequences for regional allocation. Section 6 provides a summary, conclusions, and suggestions for future research.

2. Regional Allocation Using Poverty Indicators

Among priority indicators, the two most common are probably poverty incidence (poor people / total population) and the poverty count (total poor people). Some program strategies limit activities to regions whose indicator values exceed arbitrarily-specified thresholds. More generally, budgetary allocations are guided by relative indicator values. Following the latter approach for Lao PDR, we compute regional budget shares that are proportional to the values of poverty incidence and the poverty count. Figures 2.1 - 2.3 display the results, and Table 2.1 indicates the associated priority rankings. Figure 2.1 and Table 2.1 present provincial shares on an approximate north-south axis, while Figures 2.2 and 2.3 display relative shares on a provincial map. The figures show that changing the indicator has a significant impact on provincial shares and priority rankings. Among provinces with top-five shares for poverty incidence, only two in the north (Huaphanh, Oudomxay) are in the top-five group for the poverty count. Changing the indicator from incidence to count shifts two provinces (Xaysomboon, Sekong) from the highest to the lowest group. Conversely, Savannakhet moves from the lowest to the highest group. Overall, the correlation result in Table 2.2 ($\rho = .006$) suggests that the two sets of provincial shares have effectively zero association: Allocation by one indicator creates a random result for the other.

Our conclusions are not changed when we include two measures related to the poverty gap.[3] First, we estimate a province's *total poverty gap* by summing across poverty gaps for all individuals who are estimated to fall below the poverty line. Second, we estimate provinces' *poverty severity* by squaring individual gaps before summing them. Poverty severity draws

[3] The individual poverty gap is the difference between the poverty line and the actual income of a poor individual.

attention to provinces with large numbers of people whose incomes fall far short of the poverty line.

Either measure can be used to determine provincial shares, and Table 2.2 displays the results. The two measures are highly correlated with each other ($\rho = .95$); strongly correlated with the poverty count (.96 and .88, respectively); and weakly correlated with poverty incidence (.20 and .38). While the poverty gap and poverty severity add interesting dimensions to the discussion, their introduction does not seem to alter our basic results. Either measure could substitute for the poverty count, but neither is highly correlated with poverty incidence. We conclude that alternative poverty indicators provide contradictory guidance for regional resource allocation in Lao PDR.

3. Regional Program Planning

To provide a more consistent framework, we adopt an approach to optimal regional allocation that resembles an intrafamilial allocation model developed by Behrman, Pollak and Taubman (1982). In this model, parents face the problem of allocating educational resources to children with different innate abilities. Since the children's earnings will depend on their schooling as well as their genetic endowments, the parents' allocation of educational investments will affect both the overall level and the distribution of the children's future earnings. The model formalizes the parents' choice as constrained maximization of a CES welfare function, whose arguments are the children's future earnings. Constraints include an earnings equation (a function of schooling and genetic endowment) and a fixed budget. Given these constraints, the parents' allocation is determined by their degree of aversion to inequality in their children's earnings (summarized in the CES substitution parameter) and by any exogenously-determined factors that imply differential preferences among children (the distribution parameters). Our interregional allocation model adopts essentially the same approach, for provinces instead of children.

3.1 Regional Welfare Function

Within each province, implementation of a poverty-environment program involves pursuit of four objectives: the number of poor people served by the program (weighted by their relative poverty); the proportion of poor people who are served; the quality of services (determined by program expenditure net of administrative costs); and the environmental improvement realized by the program. Formally, we specify a CES welfare function as follows:

$$(1)\quad W_i = \beta_1 E_i^{\gamma} + \beta_2 \left(\frac{S_i}{P_i}\right)^{\gamma} + \beta_3 (g_i S_i)^{\gamma} + \beta_4 N_i^{\gamma} \quad ; \quad \sum_{i=1}^{4} \beta_i = 1$$

where E_i = Program expenditure (net of administrative costs) in region i
S_i = Poor people served by the program in region i
P_i = Poverty count in region i
g_i = Average poverty gap in region i
N_i = Natural resource, environmental (or other) improvement in region i

In this formulation, the distribution parameters (β_1 - β_4) indicate relative preferences for the four objectives. The parameter γ determines the elasticity of substitution, or willingness to accept tradeoffs among objectives. Particularly interesting values for γ are 1 (associated with an infinitely-elastic, or linear, welfare function); 0 (a unit-elastic, or Cobb-Douglas, function) and $-\infty$ (a zero-elasticity, or Leontief, function). The linear case is not subject to diminishing returns, so an optimal linear solution can include zero values for some program objectives. Conversely, the Leontief case prescribes a fixed ratio of outcomes. The Cobb-Douglas case is intermediate, with moderately-diminishing returns and an implicit requirement that all objectives have non-zero values in the optimal solution.

3.2 Regional Administrative Cost Functions

We specify spatial administrative cost functions for two components of the program. For the component related to poverty and household-level pollution, we incorporate the effects of poverty density (the settlement density of poor households) and poverty incidence. We posit that the average cost of serving a poor household in a particular region is negatively related to the region's poverty density, for two reasons. The first involves transport costs, which are significant because programs often require recurrent support from administrative and technical staff. Examples include monitoring and enforcement of regulations related to pollution, cultivation of fragile lands, and forest-clearing; and technical assistance to pesticide users, sanitation projects, and programs that reduce indoor air pollution through changes in ventilation, fuel use, and facilities for cooking and heating. For regional administrative staff, the cost of travel to communities served depends on both road quality and distance from the administrative center. Characteristic distance traveled is, in turn, a function of the area administered. We use a region's poverty density to capture this spatial cost factor. A second, related element reflects program scale economies in densely-settled areas. Examples include community-level sanitation and clean-water projects that require interconnections among households, as well as technical assistance programs whose teaching and outreach components can address groups rather than individuals.

We also posit that a region's average administrative cost is negatively related to its poverty incidence. In mixed-income areas, program benefits intended for the poor may "leak" to higher-income groups in the absence of costly screening. Leakage may be particularly serious in community-level programs that address collective problems such as sanitation, water quality, reforestation and erosion control. Since screening is much easier in areas populated mostly by poor people, we use poverty incidence to capture the screening cost factor.

The following function incorporates the effect of poverty density and incidence on administrative cost per poor person served:

(2) $c_{si} = \alpha_0 D_i^{\alpha_1} I_i^{\alpha_2} \quad (\alpha_1 < 0; \alpha_2 < 0)$

where c_{si} = Administrative cost per person served in region i
D_i = Poverty density (Poverty count / Area) in region i
I_i = Poverty incidence (Poverty count / Total population) in region i

We also incorporate a spatial cost function for environmental program components that involve natural resource conservation (forests, fisheries, soils) and management of extra-household pollution (outdoor air pollution, agricultural pollution, etc.). Environmental improvement in such cases usually requires monitoring and enforcement of regulations. Increased settlement density means greater pressure on environmental resources from more sources, which in turn implies higher monitoring and enforcement costs to attain the same level of environmental quality. We formalize this effect in the following unit cost function:

(3) $c_{ni} = \phi_0 T_i^{\phi_1} \quad (\phi_1 > 0)$

where c_{ni} = Unit cost of environmental improvement in region i
T_i = Population density in region i

3.3 Regional Budget Constraint

After regional allocation of the national program budget, each region has the following budget constraint:

(4) $R_i = E_i + c_{si} S_i + c_{ni} N_i$

3.4 Optimal Allocation Across Program Objectives

For each region, program administrators must solve the following Lagrangian problem to determine the optimal allocation:

$$\text{(5) Max } L = \beta_1 E_i^{\gamma} + \beta_2 \left(\frac{S_i}{P_i} \right)^{\gamma} + \beta_3 (g_i S_i)^{\gamma} + \beta_4 N^{\gamma} + \lambda [R_i - E_i - c_{si} S_i - c_{ni} N_i]$$

First-order conditions are as follows:

$$\text{(6)} \quad \frac{\partial L}{\partial E_i} = \gamma \beta_1 E_i^{*\gamma - 1} - \lambda = 0 \Rightarrow \gamma \beta_1 E_i^{*\gamma - 1} = \lambda$$

$$\text{(7)} \quad \frac{\partial L}{\partial S_i} = \gamma \beta_2 S_i^{*\gamma - 1} P_i^{-\gamma} + \gamma \beta_3 g_i^{\gamma} S_i^{*\gamma - 1} - \lambda c_{si} = 0 \Rightarrow \frac{\gamma S_i^{*\gamma - 1} (\beta_2 P_i^{-\gamma} + \beta_3 g_i^{\gamma})}{c_{si}} = \lambda$$

$$\text{(8)} \quad \frac{\partial L}{\partial N_i} = \gamma \beta_4 N_i^{*\gamma - 1} - \lambda c_{ni} = 0 \Rightarrow \frac{\gamma \beta_4 N_i^{*\gamma - 1}}{c_{ni}} = \lambda$$

The following equations determine optimal levels of net expenditure (E^*), poor households served (S^*) and environmental improvement (N^*):

$$\text{(9)} \quad \frac{\gamma \beta_4 N_i^{*\gamma - 1}}{c_{ni}} = \gamma \beta_1 E_i^{*\gamma - 1} \Rightarrow \left(\frac{N_i^*}{E_i^*} \right)^{\gamma - 1} = \frac{\beta_1 c_{ni}}{\beta_4} \Rightarrow \frac{N_i^*}{E_i^*} = \left(\frac{\beta_1 c_{ni}}{\beta_4} \right)^{\frac{1}{\gamma - 1}}$$

$$\text{(10)} \quad N_i^* = \Theta_{Ni} E_i^* \quad \text{where} \quad \Theta_{Ni} = \left(\frac{\beta_1 c_{ni}}{\beta_4} \right)^{\frac{1}{\gamma - 1}}$$

$$\text{(11)} \quad \frac{\gamma S_i^{*\gamma - 1} (\beta_2 P_i^{-\gamma} + \beta_3 g_i^{\gamma})}{c_{si}} = \gamma \beta_1 E_i^{*\gamma - 1} \Rightarrow \left(\frac{S_i^*}{E_i^*} \right)^{\gamma - 1} = \frac{\beta_1 c_{si}}{\beta_2 P_i^{-\gamma} + \beta_3 g_i^{\gamma}}$$
$$\Rightarrow \frac{S_i^*}{E_i^*} = \left(\frac{\beta_1 c_{si}}{\beta_2 P_i^{-\gamma} + \beta_3 g_i^{\gamma}} \right)^{\frac{1}{\gamma - 1}}$$

(12) $S_i^* = \Theta_{Si} E_i^*$ where $\Theta_{Si} = \left(\dfrac{\beta_1 c_{si}}{\beta_2 P_i^{-\gamma} + \beta_3 g_i^{\gamma}} \right)^{\frac{1}{\gamma - 1}}$

(13) $R_i = E_i^* + C_{Si}^* + C_{Ni}^* = E_i^* + c_{si} S_i^* + c_{ni} N_i^* = (1 + c_{si}\Theta_{Si} + c_{ni}\Theta_{Ni}) E_i^* = \Pi_i E_i^*$

(14) $E_i^* = \dfrac{1}{\Pi_i} R_i$; $S_i^* = \Theta_{Si} E_i^* = \dfrac{\Theta_{Si}}{\Pi_i} R_i^*$; $N_i^* = \Theta_{Ni} E_i^* = \dfrac{\Theta_{Ni}}{\Pi_i} R_i^*$

Substitution back into the welfare function from (14) leads to an expression for optimal regional welfare as a function of the regional program budget:

$$W_i^* = \beta_1 E_i^{*\gamma} + \beta_2 \left(\frac{S_i^*}{P_i} \right)^{\gamma} + \beta_3 g_i^{\gamma} S_i^{*\gamma} + \beta_4 N_i^{*\gamma}$$

(15) $$= \beta_1 \left(\frac{1}{\Pi_i} \right)^{\gamma} R_i^{\gamma} + \beta_2 \left(\frac{\Theta_{Si}}{\Pi_i P_i} \right)^{\gamma} R_i^{\gamma} + \beta_3 \left(\frac{\Theta_{Si}}{\Pi_i} \right)^{\gamma} g_i^{\gamma} R_i^{\gamma} + \beta_4 \left(\frac{\Theta_{Ni}}{\Pi_i} \right)^{\gamma} R_i^{\gamma}$$

$$= \frac{\beta_1 + \beta_2 \left(\Theta_{Si} / P_i \right)^{\gamma} + \beta_3 g_i^{\gamma} \Theta_{Si}^{\gamma} + \beta_4 \Theta_{Ni}^{\gamma}}{\Pi_i^{\gamma}} R_i^{\gamma} = \Delta_i R_i^{\gamma}$$

3.5 Optimal Allocation Across Regions

Following Behrman, et al. (1982), we formalize the interregional allocation problem as constrained maximization of a CES welfare function that incorporates two factors: the degree of aversion to inequality in regional allocation, and exogenously-determined preference weights assigned to regions. The latter could be equal, or they could differentiate regions by poverty incidence, poverty count, or other political, social or environmental factors that are assigned importance by administrators. We specify the relevant welfare function and budget constraint as follows:

(16) $$W = \sum_{i=1}^{N} \eta_i W_i^{\delta} = \sum_{i=1}^{N} \eta_i \left(\Delta_i R_i^{\gamma} \right)^{\delta} = \sum_{i=1}^{N} \eta_i \Delta_i^{\delta} R_i^{\gamma\delta}$$

(17) $$R_T = \sum_{i=1}^{N} R_i$$

where η_i = exogenous preference weight for region i.

The national optimization problem is defined by the following Lagrangian:

(18) $$\text{Max } L = \sum_{i=1}^{N} \eta_i \Delta_i^{\delta} R_i^{\gamma\delta} + \lambda \left[R_T - \sum_{i=1}^{N} R_i \right]$$

Optimal regional budget shares are determined by appropriate manipulation of the first-order conditions:

(19) $$\begin{aligned} &\frac{\partial L}{\partial R_i} = \gamma\delta\eta_i \Delta_i^{\delta} R_i^{*\gamma\delta - 1} - \lambda = 0 \\ &\Rightarrow \gamma\delta\eta_i \Delta_i^{\delta} R_i^{*\gamma\delta - 1} = \lambda \\ &\Rightarrow \gamma\delta\eta_i \Delta_i^{\delta} R_i^{*\gamma\delta - 1} = \gamma\delta\eta_j \Delta_j^{\delta} R_j^{*\gamma\delta - 1} \\ &\Rightarrow \left(\frac{R_i^*}{R_j^*} \right)^{\gamma\delta - 1} = \frac{\eta_j}{\eta_i} \left(\frac{\Delta_j}{\Delta_i} \right)^{\delta} \\ &\Rightarrow \frac{R_i^*}{R_j^*} = \left(\frac{\eta_j}{\eta_i} \right)^{\frac{1}{\gamma\delta - 1}} \left(\frac{\Delta_j}{\Delta_i} \right)^{\frac{\delta}{\gamma\delta - 1}} \end{aligned}$$

(20) $$\omega_i^* = \frac{\eta_i^{\frac{1}{1-\gamma\delta}} \Delta_i^{\frac{\delta}{1-\gamma\delta}}}{\sum_{i=1}^{N} \eta_i^{\frac{1}{1-\gamma\delta}} \Delta_i^{\frac{\delta}{1-\gamma\delta}}}$$

3.6 Implications: Substitution Parameters

We begin exploring the implications of the model by considering solutions for equation (20) in three basic substitution scenarios: linear, Cobb-Douglas and Leontief. In the following discussion, we refer to γ and δ as the regional and national substitution parameters, respectively. For a Cobb-Douglas regional welfare function, $\gamma = 0$ and regional budget shares in equation (20) are strictly proportional to regional η-values, whatever the value of δ. From equation (15), each region has an identical Δ-value (equal to one in our case, since we assume that the distribution parameters ($\beta_1 \ldots \beta_4$) sum to one). With the Δ_i's and the exponents of the η_i's all equal to one, each region's budget share in equation (20) is the ratio of it's η-value to the sum of regional η-values. As (20) shows, the result also holds when the national substitution parameter (δ) is equal to zero, regardless of the value of γ, since each region's budget share again becomes the ratio of its η-value to the sum of regional η-values.

The intuition behind these results is straightforward. In the Cobb-Douglas case, budget shares for the four objectives are equal to their distribution parameters (the β_i's), which do not change across regions. Since the implicit demand functions for these objectives are unit-elastic, interregional differences in administrative costs induce exactly-compensating changes in demand, and expenditures for each objective remain the same. Constant budget shares across objectives also make Δ and Π constant across regions, implying that a dollar spent in any region provides the same welfare increase. For this basic reason, the Cobb-Douglas assumption at either regional or national levels ensures that relative shares will be affected only by the exogenously-specified regional distribution weights (η_i).

Now we consider the linear case, in which $\gamma = 1$, $\delta \to 1$, and the regional welfare function is purely additive:

(1a) $$W_i = \beta_1 E_i + \beta_2 \left(\frac{S_i}{P_i} \right) + \beta_3 \left(g_i S_i \right) + \beta_4 N_i$$

In the optimal solution that incorporates equation (1a), administrators' choices take no account of balance among objectives or distribution across regions. The implication is clear after we substitute $\gamma = 1$ into equation (20):

$$\text{(20a)} \quad \omega_i^* = \frac{\eta_i^{\frac{1}{1-\delta}} \Delta_i^{\frac{\delta}{1-\delta}}}{\sum_{i=1}^{N} \eta_i^{\frac{1}{1-\delta}} \Delta_i^{\frac{\delta}{1-\delta}}}$$

As $\delta \to 1$, the parameters of (20a) approach infinity, and the budget is allocated to a few regions with the highest products $\eta_i\Delta_i$, even if their numerical advantage is very slight. Within each region, by the same logic, the budget is allocated to the highest-value objective (E_i, S_i or N_i), even if its numerical advantage is very slight.

Finally, we consider the Leontief case ($\gamma \to -\infty$; $\delta \to -\infty$). The effect of movement toward zero substitution elasticity is most easily seen through its impact on the Θ's (equations 10 and 12) and the ω's (equation 20). As $\gamma \to -\infty$, the exponents $[1/(\gamma-1)]$ for Θ_N and Θ_S approach zero. This ensures little response to changes in relative β-values, so relative attainment levels for the four program objectives remain nearly constant. For regional shares in equation (20), as $\gamma \to -\infty$ and $\delta \to -\infty$, responsiveness declines as the exponents of η and Δ both approach zero.

3.7 Implications: Other Parameters

The other basic elements of the model are the regional distribution parameters (relative preferences for program objectives); national distribution parameters (relative preferences for different regions); and administrative cost elasticities. The impact of these parameters on outcomes increases as the regional and national substitution parameters move toward one. The cost function parameters warrant particular attention here, since they are generally neglected in priority-setting exercises. As cost elasticities increase, affecting regional unit costs of administration (c_{si} , c_{ni}), the effects propagate across objectives (through Θ_S and Θ_N) and regions (through the effects of Θ_S and Θ_N on Δ). In principle, for a "perverse" cost case, the result could be reversal of the provincial rank-ordering suggested by a budget shares analysis that ignores administrative costs.

4. An Application to Lao PDR: Cobb-Douglas Results

In Section 2, we have computed alternative provincial budget shares using relative measures of poverty incidence, the poverty count, and the poverty gap. Our discussion in Section 3.6 shows that this is equivalent to the use of poverty indicators as η-values in the optimal allocation model under Cobb-Douglas assumptions ($\gamma = 0$, $\delta = 0$, or both). In this restricted case, provincial budget shares depend only on the η-values, and are not affected by variations in welfare function weights and cost elasticities. However, the levels and distributions of activities within provinces are strongly affected by such variations. Using provincial poverty incidence as the η-variable, we illustrate these effects with two examples: the impact of changes in regional welfare function weights (the β's in equation (1)) on the number of poor people served, program quality (proxied by expenditure net of administrative costs), and environmental improvement; and the impact of changes in the administrative cost elasticity on the number of poor people served.

In the first example, we assume that administrative cost elasticities are zero and focus on provincial outcomes when parameters change for the four variables in the regional welfare equation: expenditure (E_i), poor people served (S_i), the proportion of poor people served (S_i / P_i), and environmental improvement (N_i). In four cases, we assign a weight of .70 to each objective and equal weights to the others. In the fifth case, we assign equal weights to all objectives. Figure 4.1 displays the results for S_i, E_i and N_i in the five cases.[4] Values are normalized to 100 for the case of equal utility weights. Under the Cobb-Douglas assumption, the provincial budget share for each objective is equal to its utility weight and (with constant administrative costs in this case), the proportional impact of changing utility weights is the same across provinces. Because of this equi-proportional impact, the results in Figure 4.1 are the same for each province. We use the equal-weights case as the baseline (all three objectives equal 100). When poor persons served is the primary objective, S increases by 62%, while E falls by 56% and N decreases by 69%. Assignment of primacy to S/P has a similar effect, although E drops somewhat more and N somewhat less. When program expenditure (our measure of quality) is the primary objective, S and N drop by 62% and 56%, respectively, while E increases by 181%. When environmental improvement is the primary objective, S and E decrease by 62% and 56%, while N increases by 181%.

In the second example, we maintain equal utility weights for the four regional objectives and allow the administrative cost elasticities to vary from 0 to -0.9.[5] Table 4.1 indicates changes in poor persons served for changes in α_1 (cost elasticity for poverty density) and α_2 (cost elasticity for poverty incidence).[6] When the α's change from 0 to -0.9, population served falls to 26% of its constant-cost level in Xayabouri and Borikhamxay, and rises to 2.53 times its constant-cost level in Huaphanh and Oudomxay. The provincial rankings in Table 4.2 suggest that the southern provinces are most affected by cost considerations, while the northern

[4] S, E and N are determined by equations (9) – (14).

[5] When the regional welfare function is Cobb-Douglas, the proportional impact of cost elasticity changes is the same, regardless of the weights assigned to utility function objectives. For the experiments reported in this paper, we use arbitrary scaling values for α_0 and ϕ_0 in the cost equations. Relative results for program objectives and regional allocations are invariant to the choice of these scaling values.

[6] These two parameters are in the administrative cost equation (2).

provinces are least affected. Figure 4.2 indicates the overall pattern of impact on provincial rankings.

Table 4.3 presents equivalent results for environmental improvement, while Figure 4.3 provides graphical evidence on the magnitude of the changes. In Table 4.3, changing from constant to highly-elastic implementation cost has impacts ranging from a reduction of environmental improvement to 15% of its former level in Vientiane Municipality, to an increase to 2.15 times its former level in Sekong. Again, the changes in provincial rankings seem greatest in the southern provinces. Figure 4.3 indicates that rank changes are most pronounced for provinces with the highest levels of environmental improvement in the constant-cost case.

In equation (3), we specify a general function that relates the unit cost of environmental improvement to population density. However, we recognize that particular environmental problems may warrant a different treatment of the population/environment relationship. Rural problems related to deforestation and soil degradation may provide a good example in Lao PDR. For problems in this class, a more appropriate population density measure for environmental protection costs may be rural population per unit of flat land. Areas with high flat-land population density may experience more intensive pressure to cultivate steeply-sloped, forested areas. The result may be shorter fallow periods for shifting cultivators, and additional pressure to clear forested areas as yields fall. Under these circumstances, environmental protection costs may be higher (and benefits lower) than the use of general population density would predict.

In Table 4.4, we illustrate the potential policy consequences by introducing flat-land population density into the unit cost equation (3) for environmental protection. For the comparison, we use the Cobb-Douglas assumptions ($\gamma = 0$, $\delta = 0$) and high administrative cost elasticities ($\alpha_1 = \alpha_1 =-.9$). Provincial populations served (S) are invariant to the change of density measure. For general population density, we include the environmental improvement (N) result from Table 4.3 in column 4 of Table 4.4. The result associated with the change to flat-land density is in column 5. With relatively high flat-land densities and high protection costs, the northern provinces exhibit a sharp fall in environmental improvements realized with the available budget. In contrast, lower unit costs in the Center and South produce significantly higher levels of environmental improvement in many provinces. Vientiane Municipality exhibits the highest percent environmental improvement (although both levels are relatively small), because its flat-land population density is much closer to the norm for other provinces than its general density.

5. CES Results

Moving to the CES case allows more scope for administrative discretion and a broader range of results. At the regional level, the CES substitution parameter (γ) indicates the degree to which administrators are willing to accept tradeoffs among objectives. As γ approaches its limiting values ($-\infty$ and 1), the administrators' willingness moves from zero (fixed ratios for objectives, regardless of relative costs) to infinity (willingness to accept zero outcomes for two of the three objectives (S, E, N), if focusing on the third will maximize total welfare).[7] At the national level, the substitution parameter (δ) indicates the administrators' relative aversion to differences in provincial budgetary allocations. As δ approaches its limiting values ($-\infty$ and 1), the administrators' aversion to unequal allocations moves from very strong to zero.

Figures 5.1 and 5.2 provide evidence on the impact of changes in the two substitution parameters. Again, we present provinces in approximate geographical alignment, with Phongsaly in the extreme north and Attapeu in the extreme south.[8] Figure 5.1 displays changes in optimal budget shares for different combinations of γ and δ, under the assumption of constant administrative costs and equal weights for the four regional objectives (E, S, S/P, N). In the baseline, or Cobb-Douglas, case ($\gamma = 0$, $\delta = 0$), provincial shares are proportional to provincial poverty incidence, which enters via the η-values in the national welfare equation (16). In the next column, the substitution parameters are given low and high values, respectively ($\gamma = -9$, $\delta = 0.9$). These values correspond to a low willingness to substitute among the four program objectives, and a high willingness to substitute among provinces in pursuit of the greatest total welfare. The results are not markedly different from the Cobb-Douglas results, since low substitutability among objectives makes local allocations unresponsive to differences in local conditions (except for the exogenous η-values -- the poverty incidence estimates, in this case). Two notable exceptions in the center-south, Savannakhet and Champasack, gain significantly, while budget shares fall for Xaysomboon and Sekong in the same general area. Overall allocations across the north, center and south appear little-affected.

Column 3 shows that optimal provincial shares become strikingly different when administrators' willingness to substitute among objectives is high, but willingness to substitute among provinces is low. The result (again, for constant administrative costs and equal weights on the four objectives) is a nearly flat distribution: All provincial shares lie between 4.6% and

---

[7] We use limiting values to simplify the discussion, but we recognize the common-sense restriction that would keep administrators from choosing the pairs (E>0, S=0) or (S>0, E=0) in practice. In our examples, we restrict γ and δ to the range (-9, 0.9).
[8] See Figure 2.2 for a map of Laotian provinces.

6.0%. At the same time, optimal solutions within provinces look very different. For the case of constant administrative cost, Table 5.1a displays the changes in numbers of poor people served (S) and levels of environmental improvement (N) in the shift from column 1 to column 3 of Figure 5.1. The shift produces changes in S in the range ± 100%. For N, positive changes of several hundred percent are not unusual. Table 5.1b introduces high administrative cost elasticities, with even more striking results. Because the regional welfare function is nearly linear for $\gamma = 0.9$, near-complete substitution among objectives is possible. The result in the welfare-maximizing solution is a reduction to near-zero solutions for S and N in some cases, and very large increases in others.

While column 3 of Figure 5.1 portrays a nearly-uniform allocation, column 4 moves to the opposite extreme. It corresponds to the case ($\gamma = 0.9$, $\delta = 0.9$): very high willingness to substitute across both objectives and regions. Since diminishing returns are nearly eliminated in this case, almost all resources shift to two provinces -- Oudomxay and Huaphanh, both in the north -- that promise to yield the highest total gain in welfare.

Figure 5.2 changes the scenario by introducing highly-elastic administrative costs. The result is a net shift toward the central region in column 2, an even more pronounced shift toward the this region in column 3 (in contrast to the nearly-uniform allocation in Figure 5.1) but even more focus on Oudomxay and Huaphanh in column 4.

Figure 5.3 provides evidence on the role of relative provincial costs in the high-elasticity case. For service delivery to the poor, unit costs around 10 in Oudomxay and Huaphanh contrast with costs around 95 in Xayabouri and Borikhamxay. For environmental improvement, the cost disadvantage of Vientiane Municipality is particularly striking. The service delivery cost advantage of Oudomxay and Huaphanh provides one important reason why optimal budget allocations focus on these two provinces when both γ and δ are high.

6. Summary and Conclusions

We began our illustration for Lao PDR by setting both substitution parameters at Cobb-Douglas values ($\gamma = 0$, $\delta = 0$). In the Cobb-Douglas case, optimal provincial budget shares depend solely on η-values (estimates of poverty incidence, in our illustration). Even in this scenario, however, unchanging provincial shares mask large changes in provincial activities (E, S, S/P, N) as welfare weights, administrative costs and environmental protection costs change.

When we relax the Cobb-Douglas assumptions, provincial shares change markedly as γ and δ shift over plausible ranges. Table 6.1 provides an overview of the changes, by displaying correlations and rank correlations for different parameter values. For Lao PDR, the result is a very large range of outcomes relative to the Cobb-Douglas scenario: correlations between .99 and -.81.

How should we proceed, in light of these disparate findings? Should we adhere to single indicators, on the "common sense" grounds that administrators' willingness to substitute could not be too far from the Cobb-Douglas value? In fact, we have no empirical support for this version of "common sense," nor do we know how much administrators' substitution parameters may vary across countries for political, social and institutional regions. In any case, as we have seen, different poverty indicators provide very different signals for allocation policy in Lao PDR. Since "common sense" offers little guidance, we offer the following conclusions and suggestions for further research.

First, although the CES model introduces some complexity, we believe that it is less "academic" than simple indicators as a guide to priority-setting. Sole reliance on the latter is not really an application of "common sense." Rather, it represents strong (Cobb-Douglas) restrictions on the substitution parameters in the CES model. Relaxation of the Cobb-Douglas restrictions introduces a note of realism, because it allows other considerations to play a role in the decision process. These include administrative costs, as well as political and institutional factors that affect administrators' willingness to substitute among objectives and regions. In countries with strong regional rivalries, for example, administrators' willingness to substitute among provinces may be considerably less than the unit-elastic (Cobb-Douglas) value implied by the indicators-based approach.

Second, we need to know a lot more about parameter values (objective value weights, substitution elasticities, and cost elasticities) under different country conditions. Econometric estimation of such parameters seems both feasible and important for work on the poverty-environment nexus.

Third, use of the model can lend valuable perspective, even when limited evidence is marshaled for case studies. Consider, for example, the common practice of designating a few "high-priority" regions for resource allocation. In light of column 4, Figure 5.1, we can see that this amounts to adopting very high values for γ and δ. But common practice often reflects arbitrary cutoff criteria such as "top 5" status, while our results suggest that the number of "top" regions (2 in column 4, for example) may vary widely. Logically, it is also inconsistent to assign "top" status using poverty indicators alone, since these reflect Cobb-Douglas assumptions that are explicitly violated by the cutoff procedure. In our view, use of the optimizing approach can encourage more consistent selection of focal provinces in cases where administrators choose to adopt the "priority regions" approach.

Fourth, even when we have better evidence about administrators' tradeoffs, we will not be able to avoid a basic, normative question: Whatever the current values of the decision parameters, are they the "right" values? As we have seen, even our relatively simple model can generate a very broad range of outcomes for empirically-plausible changes in substitution elasticities. We cannot escape the question, since any recommended allocation of resources will reflect implicit values of these parameters.

On the other hand, we would not escape difficult questions, even if we adopted the Cobb-Douglas restrictions and allocated provincial budgets via simple indicators. As we have seen, the rank correlation of Laotian provincial shares based on poverty incidence and poverty count is effectively zero (.006). Within the indicators framework, there is no clear criterion for choosing between the two allocations. Broadening the framework to include other factors may offer a way out, and this is precisely what the CES approach offers.

To illustrate the potential, we close by computing regional shares for two CES cases. In each case, we assume high administrative cost elasticities and equal weights for program elasticities. The first case assumes that administrators' willingness to substitute is high among objectives, but low among regions. The second case assumes the converse. We compute rank correlations for provincial shares when the η-values are, respectively, poverty incidence (PI) and the poverty count (PC). For PI, provincial shares have a rank correlation of .98 between the high-low and low-high substitution scenarios. For PC, the rank correlation is .99. For mixed cases, (e.g., PI [γ high, δ low] vs. PC [γ low, δ high]), rank correlations for provincial shares are all in the range .50 - .60. These results contrast strongly with zero rank correlation when PI and PC are used as simple indicators to guide provincial allocations.

These results provide a hopeful conclusion to our exercise for Lao PDR. We have shown that simple poverty indicators do not provide consistent guidelines for policy, nor do they take account of differences in administrators' preferences and costs. However, when different poverty indicators are embedded in an optimizing model that does incorporate preferences and costs, the resulting provincial allocations are very similar. For Lao PDR, at least, movement toward optimization seems to promote harmonization of regional policy guidelines.

References

Behrman, J., R. Pollak, and P. Taubman, 1982, "Parental Preferences and Provision for Progeny," **Journal of Political Economy**, 90, 1, pp. 52 - 73.

Dasgupta, S., U. Deichmann, C. Meisner and D. Wheeler, 2003, "The Poverty/Environment Nexus in Cambodia and Lao People's Democratic Republic," **World Bank Development Research Group Working Paper**, No. 2960, January.

Simler, K. and V. Nhate, 2002, "Poverty, Inequality and Geographic Targeting: Evidence From Small-Area Estimates in Mozambique," prepared for the Northeast Universities Development Consortium Conference, Williams College, October 25-27.

Lanjouw, P., J. Lanjouw, J. Hentschel and J. Poggi, 1998, "Combining Census and Survey Data to Study Spatial Dimensions of Poverty," **World Bank Development Research Group Working Paper**, No. 1928, June.

Table 2.1 Ranked Provincial Budget Shares (Highest = 1)

Region	Province	Poverty Incidence Rank	Poverty Count Rank
North	Phongsaly	3	8
North	Luangnamtha	6	12
North	Oudomxay	2	5
North	Bokeo	9	14
North	Luangphrabang	10	4
North	Huaphanh	1	3
North	Xayabouri	17	13
Center	Vientiane Municipality	18	10
Center	Xiengkhuang	11	9
Center	Vientiane	16	11
Center	Borikhamxay	15	16
Center	Khammuane	12	7
Center	Savannakhet	14	1
Center	Xaysomboon	4	18
South	Saravane	8	6
South	Sekong	5	17
South	Champasack	13	2
South	Attapeu	7	15

Table 2.2: Rank Correlations of Budget Shares by Poverty Index

	Incidence	Count	Gap
Count	0.006		
Gap	0.203	0.959	
Severity	0.377	0.878	0.953

Table 4.1: Impact of Cost Elasticity (α) Change on Poor People Served ('000)

Region	Province	$\alpha_1,\alpha_2 = 0$	$\alpha_1,\alpha_2 = -0.9$	Ratio
North	Phongsaly	7.66	8.91	1.16
North	Luangnamtha	6.65	6.84	1.03
North	Oudomxay	8.85	22.43	2.53
North	Bokeo	5.28	4.51	0.85
North	Luangphrabang	5.28	5.36	1.01
North	Huaphanh	9.53	24.10	2.53
North	Xayabouri	2.53	0.67	0.26
Center	Vientiane Munic.	1.87	1.92	1.03
Center	Xiengkhuang	5.20	3.87	0.74
Center	Vientiane	3.05	1.40	0.46
Center	Borikhamxay	3.13	0.81	0.26
Center	Khammuane	5.20	4.88	0.94
Center	Savannakhet	4.72	6.54	1.39
Center	Xaysomboon	7.18	6.88	0.96
South	Saravane	5.58	8.86	1.59
South	Sekong	6.74	4.77	0.71
South	Champasack	4.99	8.21	1.64
South	Attapeu	6.56	4.92	0.75

Table 4.2: Impact of Cost Elasticity (α) Change on Provincial Ranking for Poor People Served

		Province Rank		Rank
Region	Province	$\alpha_1,\alpha_2 = 0$	$\alpha_1,\alpha_2 = -0.9$	Difference
North	Phongsaly	3	3	0
North	Luangnamtha	6	7	1
North	Oudomxay	2	2	0
North	Bokeo	9	13	4
North	Luangphrabang	10	9	-1
North	Huaphanh	1	1	0
North	Xayabouri	17	18	1
Center	Vientiane Municipality	18	15	-3
Center	Xiengkhuang	11	14	3
Center	Vientiane	16	16	0
Center	Borikhamxay	15	17	2
Center	Khammuane	11	11	0
Center	Savannakhet	14	8	-6
Center	Xaysomboon	4	6	2
South	Saravane	8	4	-4
South	Sekong	5	12	7
South	Champasack	13	5	-8
South	Attapeu	7	10	3

Table 4.3: Impact of Cost Elasticity (ϕ) Change on Environmental Improvement

		Environmental Improvement			Province Rank		Rank Difference
Region	Province	$\phi = 0$	$\phi = 0.9$	Ratio	$\phi = 0$	$\phi = 0.9$	
North	Phongsaly	95.73	157.44	1.64	3	4	1
North	Luangnamtha	83.08	119.65	1.44	6	6	0
North	Oudomxay	110.61	108.32	0.98	2	7	5
North	Bokeo	65.99	75.68	1.15	9	9	0
North	Luangphrabang	65.99	63.71	0.97	10	11	1
North	Huaphanh	119.15	133.74	1.12	1	5	4
North	Xayabouri	31.63	31.12	0.98	17	16	-1
Center	Vientiane Municipality	23.42	3.47	0.15	18	18	0
Center	Xiengkhuang	64.96	83.09	1.28	11	8	-3
Center	Vientiane	38.12	30.25	0.79	16	17	1
Center	Borikhamxay	39.15	57.66	1.47	15	12	-3
Center	Khammuane	64.96	65.93	1.01	11	10	-1
Center	Savannakhet	58.98	34.08	0.58	14	14	0
Center	Xaysomboon	89.75	159.63	1.78	4	2	-2
South	Saravane	69.75	47.53	0.68	8	13	5
South	Sekong	84.28	181.44	2.15	5	1	-4
South	Champasack	62.40	33.60	0.54	13	15	2
South	Attapeu	82.06	158.68	1.93	7	3	-4

Table 4.4: Environmental Improvement: Impact of Changing the Population Density Measure

Cost Determinant			Population Density	Flat-Land Population Density	% Change
Region	Province	S	N	N	
North	Phongsaly	8.91	157.44	63.65	-59.57
North	Luangnamtha	6.84	119.65	70.97	-40.69
North	Oudomxay	22.43	108.32	58.50	-45.99
North	Bokeo	4.51	75.68	47.03	-37.86
North	Luangphrabang	5.36	63.71	25.13	-60.55
North	Huaphanh	24.10	133.74	55.97	-58.15
North	Xayabouri	0.67	31.12	22.65	-27.23
Center	Vientiane Municipality	1.92	3.47	14.49	317.53
Center	Xiengkhuang	3.87	83.09	43.88	-47.18
Center	Vientiane	1.40	30.25	34.33	13.49
Center	Borikhamxay	0.81	57.66	49.43	-14.27
Center	Khammuane	4.88	65.93	86.35	30.97
Center	Savannakhet	6.54	34.08	62.73	84.08
Center	Xaysomboon	6.88	159.63	229.13	43.54
South	Saravane	8.86	47.53	33.83	-28.83
South	Sekong	4.77	181.44	330.09	81.93
South	Champasack	8.21	33.60	44.31	31.87
South	Attapeu	4.92	158.68	95.85	-39.60

Table 5.1: Regional Allocations Under Parametric Changes

(a): Constant Administrative Costs

γ		0		High		% Changes	
δ		0		Low			
Cost		Constant		Constant			
Region	Province	S	N	S	N	S	N
North	Phongsaly	7.66	95.73	8.84	51.33	15.5	-46.4
North	Luangnamtha	6.65	83.08	8.30	67.72	24.9	-18.5
North	Oudomxay	8.85	110.61	8.90	6.31	0.6	-94.3
North	Bokeo	5.28	65.99	5.97	137.39	13.2	108.2
North	Luangphrabang	5.28	65.99	5.90	139.80	11.7	111.9
North	Huaphanh	9.53	119.15	9.41	17.61	-1.3	-85.2
North	Xayabouri	2.53	31.63	0.43	272.67	-83.1	762.2
Center	Vientiane Municipality	1.87	23.42	2.04	218.45	9.1	832.7
Center	Xiengkhuang	5.20	64.96	5.88	139.87	13.1	115.3
Center	Vientiane	3.05	38.12	0.71	270.81	-76.7	610.4
Center	Borikhamxay	3.13	39.15	5.77	125.67	84.3	221.0
Center	Khammuane	5.20	64.96	4.55	179.63	-12.5	176.5
Center	Savannakhet	4.72	58.98	1.94	250.94	-59.0	325.5
Center	Xaysomboon	7.18	89.75	9.05	35.38	26.1	-60.6
South	Saravane	5.58	69.75	5.35	158.39	-4.2	127.1
South	Sekong	6.74	84.28	8.74	49.54	29.7	-41.2
South	Champasack	4.99	62.40	4.29	185.72	-14.0	197.6
South	Attapeu	6.56	82.06	6.58	126.42	0.2	54.1

(b) Variable Administrative Costs

γ		0		High		% Changes	
δ		0		Low			
Cost		High-Elasticity		High-Elasticity			
Region	Province	S	N	S	N	S	N
North	Phongsaly	8.91	157.44	1.84	339.93	-79.3	115.9
North	Luangnamtha	6.84	119.65	1.47	343.07	-78.5	186.7
North	Oudomxay	22.43	108.32	12.35	0.00	-44.9	-100.0
North	Bokeo	4.51	75.68	0.80	350.65	-82.3	363.3
North	Luangphrabang	5.36	63.71	8.87	127.88	65.6	100.7
North	Huaphanh	24.10	133.74	13.70	0.01	-43.2	-100.0
North	Xayabouri	0.67	31.12	0.00	344.88	-100.0	1008.4
Center	Vientiane Municipality	1.92	3.47	15.48	0.00	705.6	-100.0
Center	Xiengkhuang	3.87	83.09	0.07	380.81	-98.2	358.3
Center	Vientiane	1.40	30.25	0.00	343.63	-99.7	1036.0
Center	Borikhamxay	0.81	57.66	0.00	369.07	-100.0	540.1
Center	Khammuane	4.88	65.93	3.21	277.83	-34.2	321.4
Center	Savannakhet	6.54	34.08	18.01	0.37	175.6	-98.9
Center	Xaysomboon	6.88	159.63	0.21	401.97	-96.9	151.8
South	Saravane	8.86	47.53	16.12	0.10	81.9	-99.8
South	Sekong	4.77	181.44	0.00	418.53	-100.0	130.7
South	Champasack	8.21	33.60	16.60	0.01	102.2	-100.0
South	Attapeu	4.92	158.68	0.00	412.38	-100.0	159.9

Table 6.1: Correlations of Provincial Shares Across Parameter Changes

(a) Correlations with Cobb-Douglas allocation:
Constant Administrative Costs

	Cobb-Douglas	γ Low , δ High	γ High , δ Low
γ Low , δ High	0.27		
γ High , δ Low	-0.54	0.04	
γ High , δ High	0.73	0.39	-0.82

(b) Correlations with Cobb-Douglas allocation:
High Administrative Cost Elasticity

	Cobb-Douglas	γ Low , δ High	γ High , δ Low
γ Low , δ High	-0.56		
γ High , δ Low	-0.81	0.52	
γ High , δ High	0.64	-0.23	-0.66

(c) Rank Correlations with Cobb-Douglas allocation:
Constant Administrative Costs

	Cobb-Douglas	γ Low , δ High	γ High , δ Low
γ Low , δ High	0.05		
γ High , δ Low	-0.47	0.31	
γ High , δ High	0.99	0.04	-0.49

(d) Rank Correlations with Cobb-Douglas allocation:
High Administrative Cost Elasticity

	Cobb-Douglas	γ Low , δ High	γ High , δ Low
γ Low , δ High	-0.62		
γ High , δ Low	-0.78	0.49	
γ High , δ High	0.96	-0.63	-0.87

Figure 2.1 Laotian Provincial Poverty Indicators and Associated Budget Shares (%)

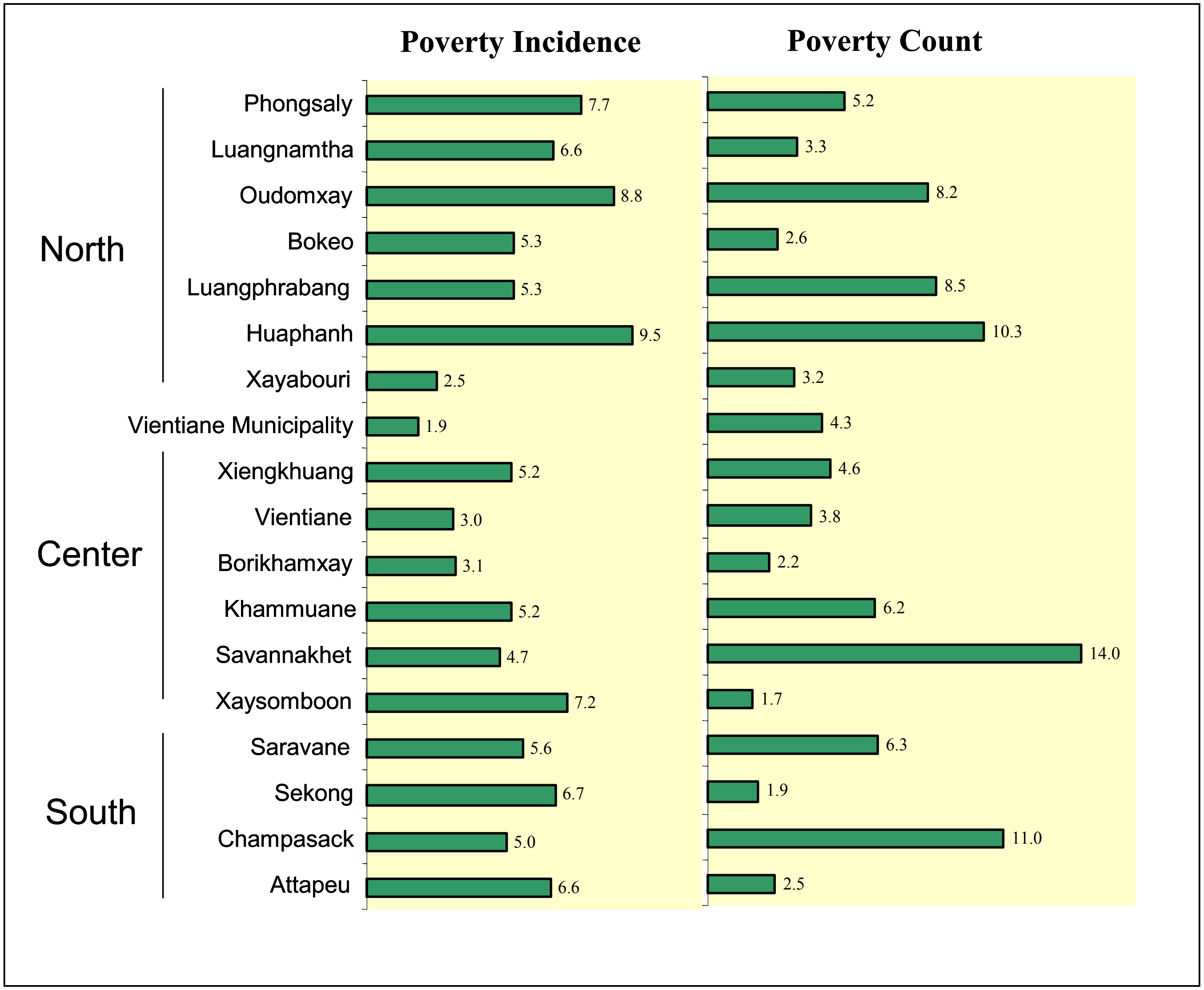

Figure 2.2: Province Rankings by Poverty Incidence

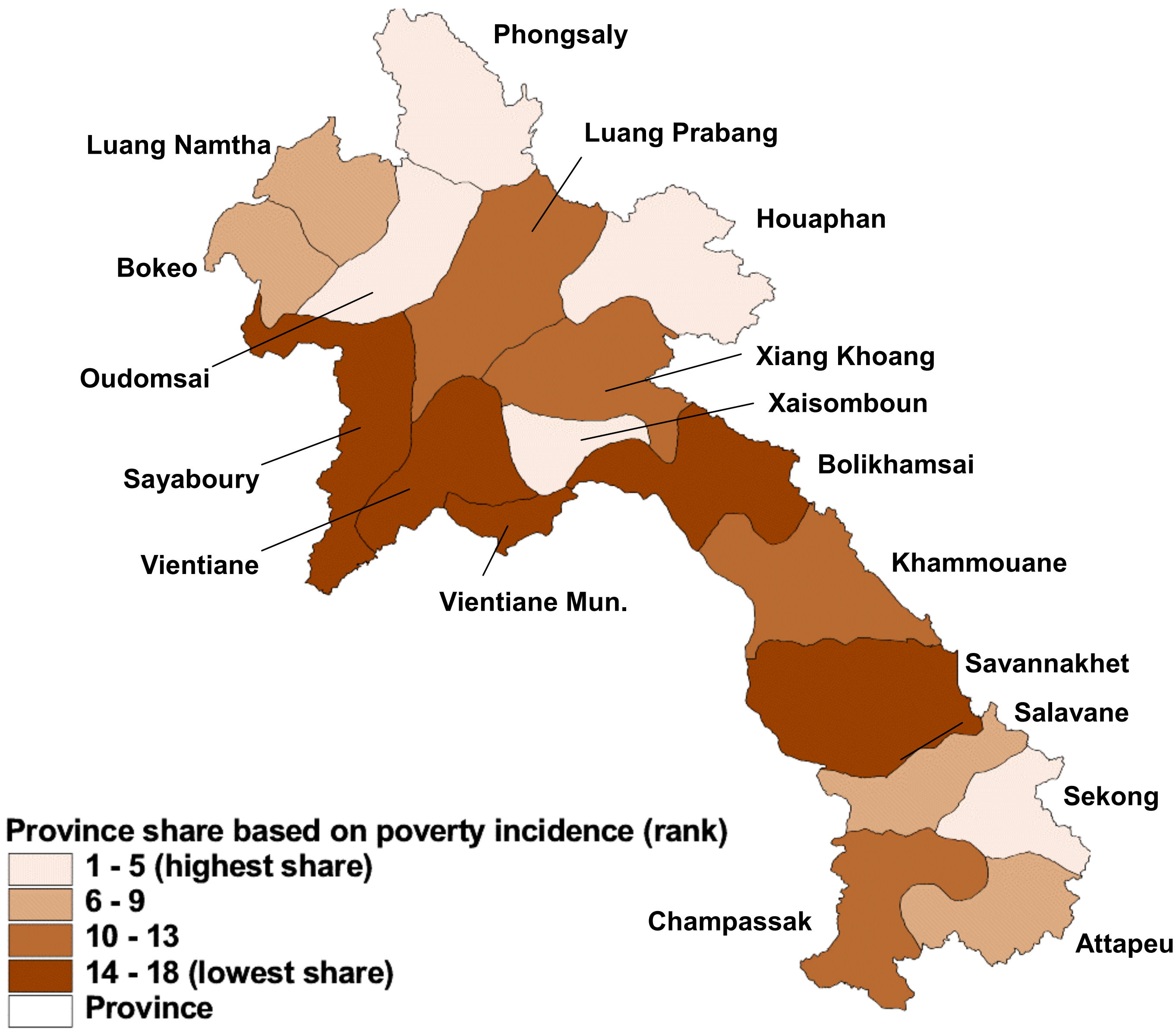

Figure 2.3: Province Rankings by Poverty Count

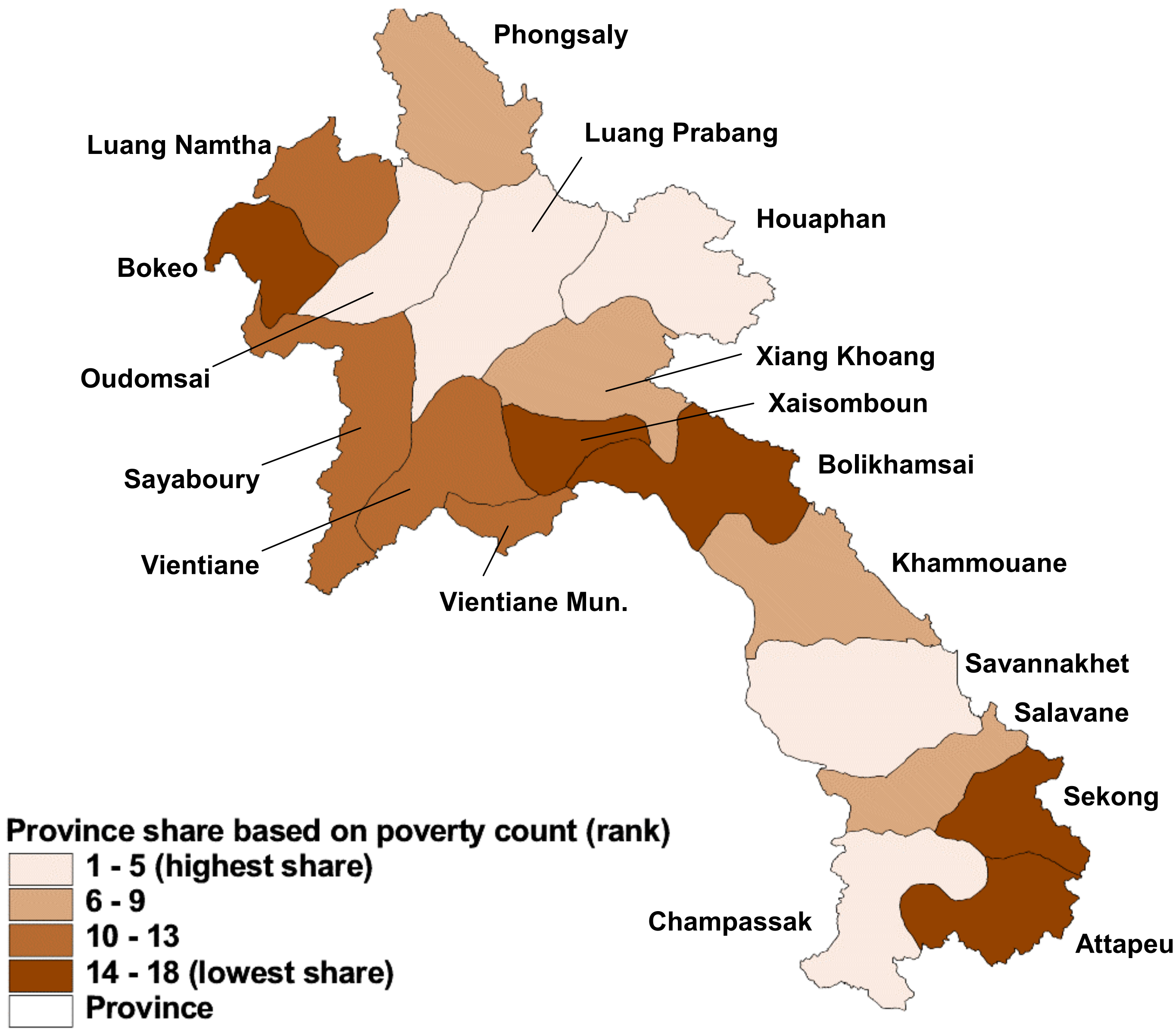

Figure 4.1: Welfare Weights and Program Outcomes: Cobb-Douglas Case

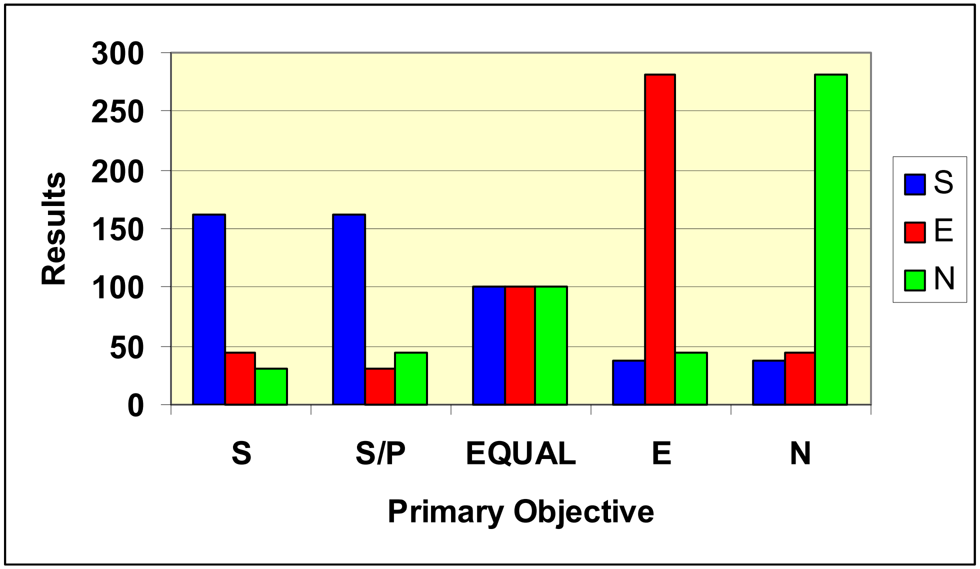

Figure 4.2: Poor Persons Served: Cost Elasticities and Province Rankings

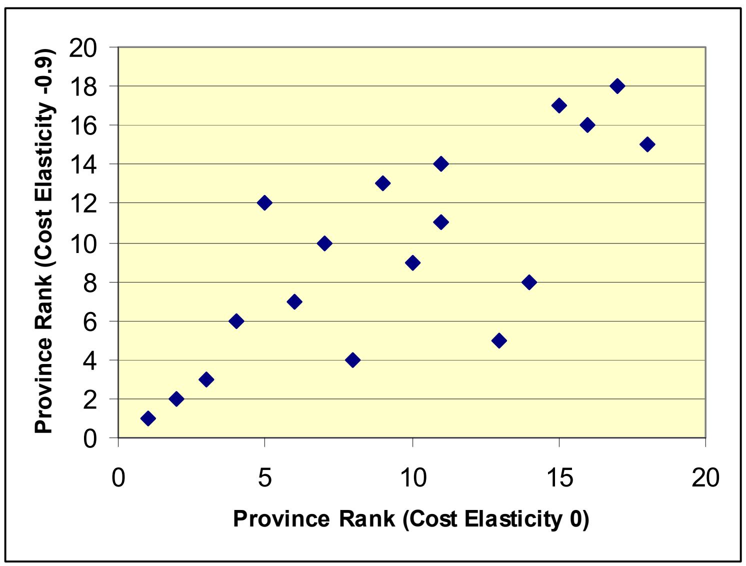

Figure 4.3: Environmental Improvement: Cost Elasticities and Province Rankings

Error! Not a valid link.

Figure 5.1 Substitution Parameter Values and Provincial Allocations (%) (Constant Administrative Costs)

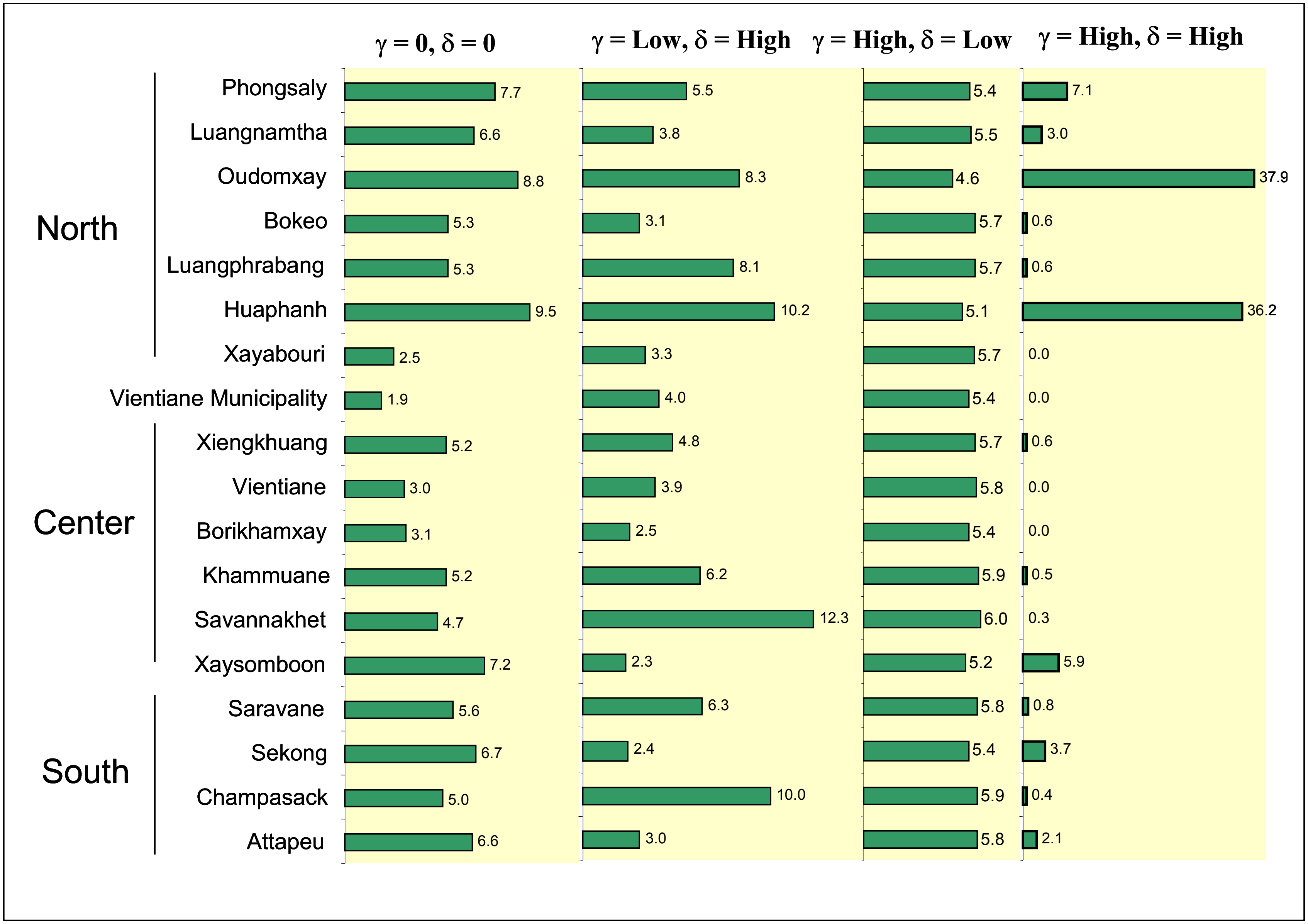

Figure 5.2 Substitution Parameter Values and Provincial Allocations (%) (Variable Administrative Costs)

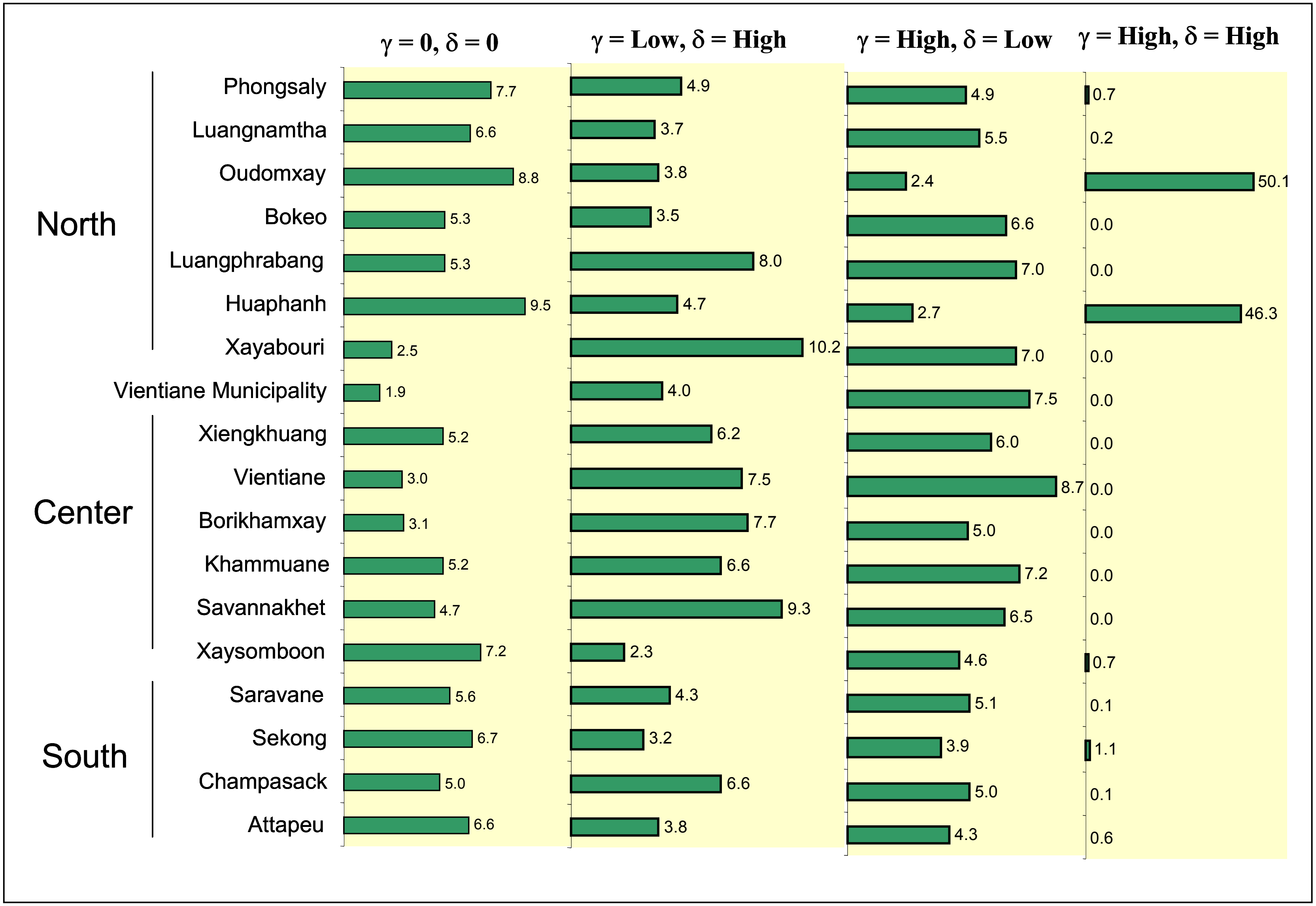

Figure 5.3: Provincial Unit Administrative Costs: High-Elasticity Case